



Funding and Strategic Alignment Guidance for Infusing Small Business Innovation Research Technology Into Human Exploration and Operations Mission Directorate Projects at Glenn Research Center for 2015

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Abstract

This report is intended to help NASA program and project managers incorporate Glenn Research Center Small Business Innovation Research/Small Business Technology Transfer (SBIR)/(STTR) technologies into NASA Human Exploration and Operations Mission Directorate (HEOMD) programs and projects. Other Government and commercial project managers can also find this useful.

Introduction

Incorporating Small Business Innovation Research (SBIR)-developed technology into NASA projects is important, especially given the Agency's limited resources for technology development. The SBIR program's original intention was for technologies that had completed Phase II to be ready for integration into NASA programs, however, in many cases there is a gap between Technology Readiness Levels (TRLs) 5 and 6 that needs to be closed.

After SBIR Phase II projects are completed, the technology is evaluated against various parameters and a TRL rating is assigned. Most programs tend to adopt more mature technologies—at least TRL 6 to reduce the risk to the mission rather than adopt TRLs between 3 and 5 because those technologies are perceived as too risky. The gap between TRLs 5 and 6 is often called the “Valley of Death” (Figure 1), and historically it has been difficult to close because of a lack of funding support from programs. Several papers have already suggested remedies on how to close the gap (Refs. 1 to 4).

SBIR Solicitation Process

Understanding how the SBIR solicitation process works should help small businesses and Human Exploration and Operations Mission Directorate (HEOMD) project managers form partnerships to incorporate SBIR technologies into NASA programs and projects. For example, when HEOMD program managers identify specific SBIR subtopics that are likely to generate technologies that could apply to their programs or projects, the SBIR office would provide information about previously developed technologies that could be incorporated into their work. Small business principal investigators (PIs) would also benefit from understanding NASA program and project needs, thus increasing the likelihood that the technologies they developed will be infused into HEOMD programs and projects. The fiscal year (FY) 2015 and 2014 solicitations are posted at <http://sbir.gsfc.nasa.gov/solicitations>.

Integrating SBIR-developed technology into NASA programs and projects is important, especially given the Agency's limited resources for technology development. The SBIR program's original intent was for technologies that had completed Phase II to be ready for integration into NASA programs. Now the SBIR program supports its small business partners with three post-Phase II options that focus on creating opportunities for commercialization as well as technology integration. The Phase II Enhancement

		TRL	Description
SBIR Phases I and II	Basic research	1	Basic scientific/engineering principles observed and reported
	Feasibility research	2	Technology concept, application, and potential benefits formulated (candidate system selected)
	Feasibility research	3	Analytic and/or experimental proof-of-concept completed (breadboard test)
	Technology development	4	System concept observed in laboratory environment (candidate system selected)
Technology demonstration "Valley of Death"	Technology development	5	System concept tested and potential benefits substantiated in a controlled relevant environment
	System development	6	Prototype of system concept is demonstrated in a relevant environment
System development	System development	7	System prototype is tested and potential benefits substantiated more broadly in a relevant environment
	Operational verification	8	Actual system constructed and demonstrated with benefits substantiated in a relevant environment
	Operational verification	9	Operational use of actual system tested with benefits proven

Figure 1.—Technology Readiness Levels (TRLs).

(Phase II-E), Phase II Expanded (Phase II-X), and Commercialization Readiness Pilot (CRP) options also provide opportunities for Phase II technologies to be integrated and tested in the NASA system platform or in the space environment.

The three post-Phase II options, which typically last between 6 and 36 months, create more opportunities to advance technology maturity, reduce associated risks, and increase the likelihood for integrating technology into NASA, Department of Defense (DoD), or external entity programs.

- Phase II-E: This option advances Phase II innovations by extending existing Phase II contracts. Under Phase II-E extensions, NASA SBIR will match, investments in technology development that small businesses secure from eligible non-NASA SBIR third parties on a dollar-for-dollar basis. The minimum matching investment is \$25,000 and the maximum is \$150,000, extending projects by 6 to 12 months.
- Phase II-X: This option establishes a strong and direct partnership between the SBIR program and NASA programs and projects undertaking new technology development. Under Phase II-X expansions, NASA SBIR will double the funding that small businesses secure from non-SBIR NASA programs or projects. The minimum investment that NASA SBIR will double is \$75,000 and the maximum is \$250,000. Expanded projects last between 12 and 24 months.
- The Commercialization Readiness Program (CRP): This option accelerates transition of SBIR-developed technologies into NASA applications. Projects that request SBIR funding under the CRP option must (1) involve a technology that entered into either a Phase I or Phase II contract and (2) identify how more SBIR funding would accelerate development in response to NASA program or project needs. The minimum matching investment is \$100,000 and the maximum is \$1.5 million, extending projects by 24 to 36 months.

Table I summarizes the three post-Phase II options.

HEOMD subtopics that Glenn leads and participates in for FY 2015 Phase I are shown in Figure 2 and their solicitation descriptions are listed in Chapter 9 of the FY 2015 Phase I SBIR solicitation.

HEOMD subtopics that GRC leads and participates in for FY 2014 Phase II are shown in Figure 3 and their solicitation descriptions are listed in Chapter 9 of the FY 2014 Phase I SBIR solicitation.

TABLE I.—NASA SBIR POST-PHASE II FUNDING OPTIONS

Criteria	Phase II-E	Phase II-X ^a	CRP
Purpose	Advance SBIR technology by extending current Phase II contracts	Establish partnerships between NASA programs and projects and non-SBIR companies	Accelerate transition of SBIR-developed technologies into NASA applications
Funding source	Any eligible non-NASA SBIR third party	NASA program or project	Either eligible NASA program or project or non-NASA SBIR third party
Minimum, dollars	\$25,000	\$75,000	\$0
Maximum, dollars	\$150,000	\$250,000	\$0
SBIR match	1:1	2:1	Up to \$1,500,000
Performance period, months	6 to 12	12 to 24	24 to 36

^aBeginning in FY 2012

Topics and Subtopics

H1 In-Situ Resource Utilization

H1.01 Regolith ISRU for Mission Consumable Production

H2 Space Transportation

H2.01 In-Space Chemical Propulsion
H2.02 Nuclear Thermal Propulsion
H2.03 High Power Electric Propulsion
H2.04 Cryogenic Fluid Management for In-Space Transportation

H3 Life Support and Habitation Systems

H3.01 Environmental Monitoring for Spacecraft Cabins
H3.03 Spacecraft Cabin Atmosphere Quality and Thermal Management

H4 Extra-Vehicular Activity and Crew Survival Systems Technology

H4.03 EVA Space Suit Power, Avionics, and Software Systems

H5 Lightweight Spacecraft Materials and Structures

H5.01 Deployable Structures
H5.03 Multifunctional Materials and Structures

H7 Entry, Descent, and Landing Technologies

H7.01 Ablative Thermal Protection Systems Technologies, Sensors, and NDE Methods

H8 High Efficiency Space Power Systems

H8.01 Space Nuclear Power Systems
H8.02 Solid Oxide Fuel Cells and Electrolyzers
H8.03 Advanced Photovoltaic Systems

H9 Space Communications and Navigation

H9.01 Long Range Optical Telecommunications
H9.02 Intelligent Communication Systems
H9.03 Flight Dynamics and Navigation Technology

H10 Ground Processing

H10.01 Cryogenic Purge Gas Recovery and Reclamation

H12 Human Research and Health Maintenance

H12.01 Measurements of Net Ocular Blood Flow

H13 Non-Destructive Evaluation

H13.02 NDE Sensors

H14 International Space Station Demonstration and Development of Improved Exploration Technologies and Increased ISS Utilization

H14.01 International Space Station Utilization

Figure 2.—HEOMD subtopics that Glenn leads and participates in for FY 2015 Phase I.

Topics and Subtopics

H1 In-Situ Resource Utilization H1.01 In-Situ Resource Utilization - Mars Atmosphere/ Gas Chemical Processing	H8 High Efficiency Space Power Systems H8.01 Solid Oxide Fuel Cells and Electrolyzers H8.02 Space Nuclear Power Systems
H2 Space Transportation H2.01 High Power Electric Propulsion H2.02 In-Space Chemical Propulsion H2.03 Nuclear Thermal Propulsion (NTP)	H9 Space Communications and Navigation H9.01 SCan Testbed Experiments H9.02 Long Range Optical Telecommunications H9.03 Long Range Space RF Telecommunications H9.04 Flight Dynamics GNC Technologies and Software H9.05 Advanced Celestial Navigation Techniques and Systems for Deep-Space Applications
H3 Life Support and Habitation Systems H3.01 Thermal Control for Future Human Exploration Vehicles H3.02 Atmosphere Revitalization and Fire Recovery for Future Exploration Missions	H10 Ground Processing and ISS Utilization H10.02 International Space Station Utilization
H5 Lightweight Spacecraft Materials and Structures H5.01 Additive Manufacturing of Lightweight Metallic Structures H5.02 Deployable Structures	H12 Human Research and Health Maintenance H12.01 Next Generation Oxygen Concentrator for Medical Scenarios
H7 Entry, Descent, and Landing Technologies H7.01 Advanced Thermal Protection Systems Technologies	H13 Non-Destructive Evaluation H13.01 Advanced NDE Techniques for Complex Built Up Structures H13.02 Advanced Structural Health Monitoring

Figure 3.—HEOMD subtopics that Glenn leads and participates in for FY 2014 Phase II.

Phase I and II Contract Awards

The number of Phase I and II contracts associated with GRC HEOMD subtopics are summarized in Table II and Table III.

TABLE II.—CONTRACT AWARDS ASSOCIATED WITH HEOMD SUBTOPICS
THAT GLENN LEADS AND PARTICIPATES IN FOR FISCAL YEAR 2015 PHASE I

Subtopic ^a		Awards
H1.01	Regolith ISRU for Mission Consumable Production	6
H2.01	In-Space Chemical Propulsion	7
H2.02	Nuclear Thermal Propulsion	4
H2.03	High Power Electric Propulsion	2
H2.04	Cryogenic Fluid Management for In-Space Transportation	6
H3.01	Environmental Monitoring for Spacecraft Cabins	5
H3.03	Spacecraft Cabin Atmosphere Quality and Thermal Management	5
H4.03	EVA Space Suit Power, Avionics, and Software Systems	3
H5.01	Deployable Structures	6
H5.03	Multifunctional Materials and Structures	4
H7.01	Ablative Thermal Protection Systems Technologies, Sensors and NDE Methods	4
H8.01	Space Nuclear Power Systems	2
H8.02	Solid Oxide Fuel Cells and Electrolyzers	2
H8.03	Advanced Photovoltaic Systems	2
H9.01	Long Range Optical Telecommunications	7
H9.02	Intelligent Communication Systems	1
H9.03	Flight Dynamics and Navigation Technology	2
H10.01	Cryogenic Purge Gas Recovery and Reclamation	5
H12.01	Measurements of Net Ocular Blood Flow	1
H13.02	NDE Sensors	4
H14.01	International Space Station (ISS) Utilization	6

^aSee Appendix A for contract titles.

TABLE III.—CONTRACT AWARDS ASSOCIATED WITH HEOMD SUBTOPICS
THAT GLENN LEADS AND PARTICIPATES IN FOR FISCAL YEAR 2014 PHASE II

Subtopic ^a		Awards
H1.01	In-Situ Resource Utilization - Mars Atmosphere/Gas Chemical Processing	2
H2.01	High Power Electric Propulsion	2
H2.02	In-Space Chemical Propulsion	2
H2.03	Nuclear Thermal Propulsion	2
H3.01	Thermal Control for Future Human Exploration Vehicles	1
H3.02	Atmosphere Revitalization and Fire Recovery for Future Exploration Missions	3
H5.01	Additive Manufacturing of Lightweight Metallic Structures	2
H5.02	Deployable Structures	2
H7.01	Advanced Thermal Protection Systems Technologies	3
H8.01	Solid Oxide Fuel Cells and Electrolyzers	2
H8.02	Space Nuclear Power Systems	1
H9.01	SCaN Testbed (CoNNeCT) Experiments	0
H9.02	Long Range Optical Telecommunications	1
H9.03	Long Range Space RF Telecommunications	1
H9.04	Flight Dynamics GNC Technologies and Software	0
H9.05	Advanced Celestial Navigation Techniques and Systems for Deep-Space Applications	1
H10.02	International Space Station (ISS) Utilization	2
H12.01	Next Generation Oxygen Concentrator for Medical Scenarios	1
H13.01	Advanced NDE Techniques for Complex Built Up Structures	1
H13.02	Advanced Structural Health Monitoring	1

^aSee Appendix B for contract titles.

HEOMD Program and Project Summaries

FY 2015 and FY 2014 GRC HEOMD topics and subtopics strategically align with HEOMD programs and projects, and support the directorate's current needs and objectives. To help small business PIs and HEOMD project managers, it is important to understand how the SBIR subtopics are mapped to HEOMD programs and projects for FY 2015 and FY 2014, respectively, as shown in Figure 4 and Figure 5. HEOMD program and project descriptions follow.



Figure 4.—Subtopics that Glenn leads or participates in mapped to HEOMD programs and Projects for FY 2015.

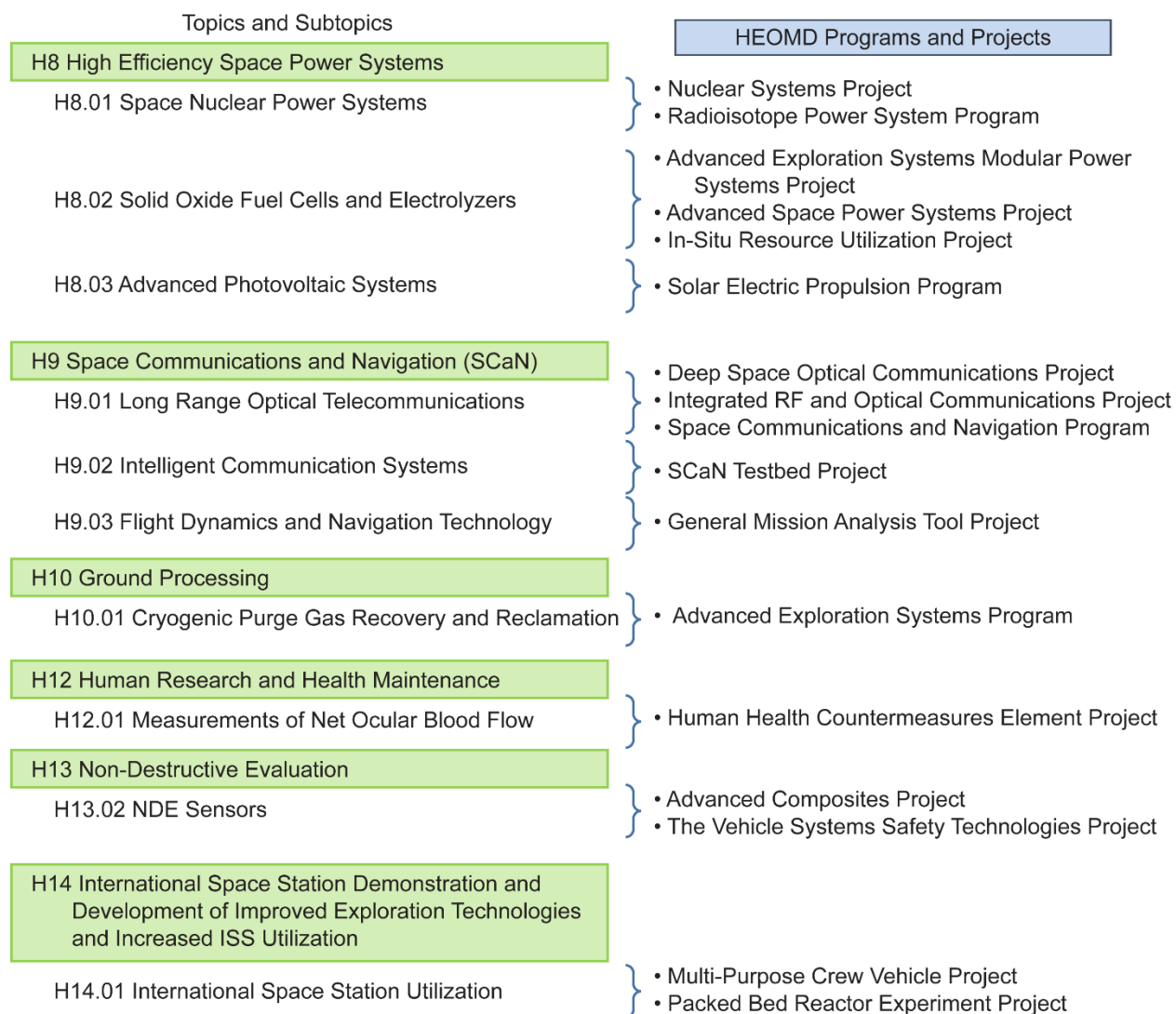


Figure 4.—Concluded.

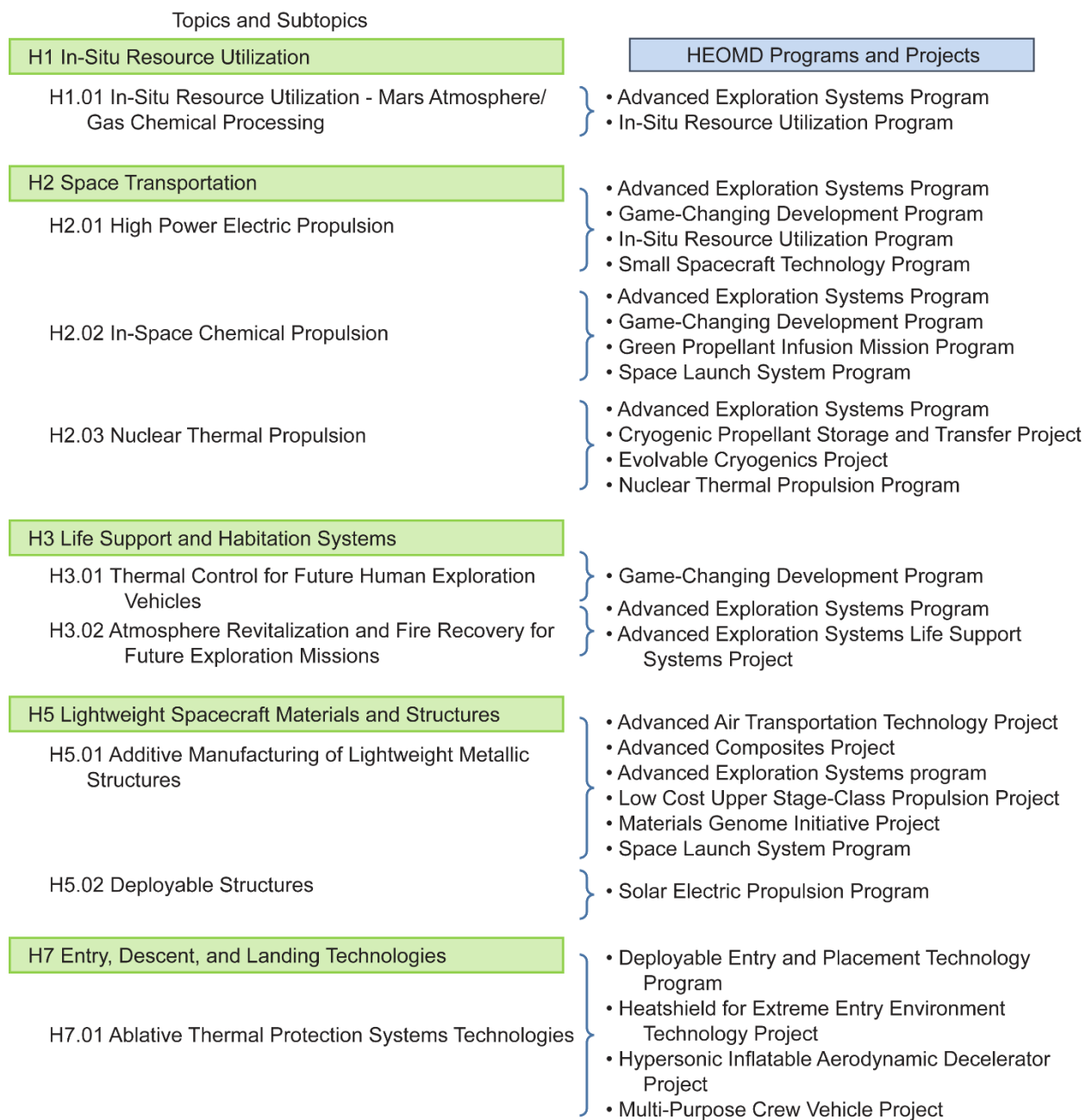


Figure 5.—Subtopics that Glenn leads or participates in mapped to HEOMD programs and Projects for FY 2014.

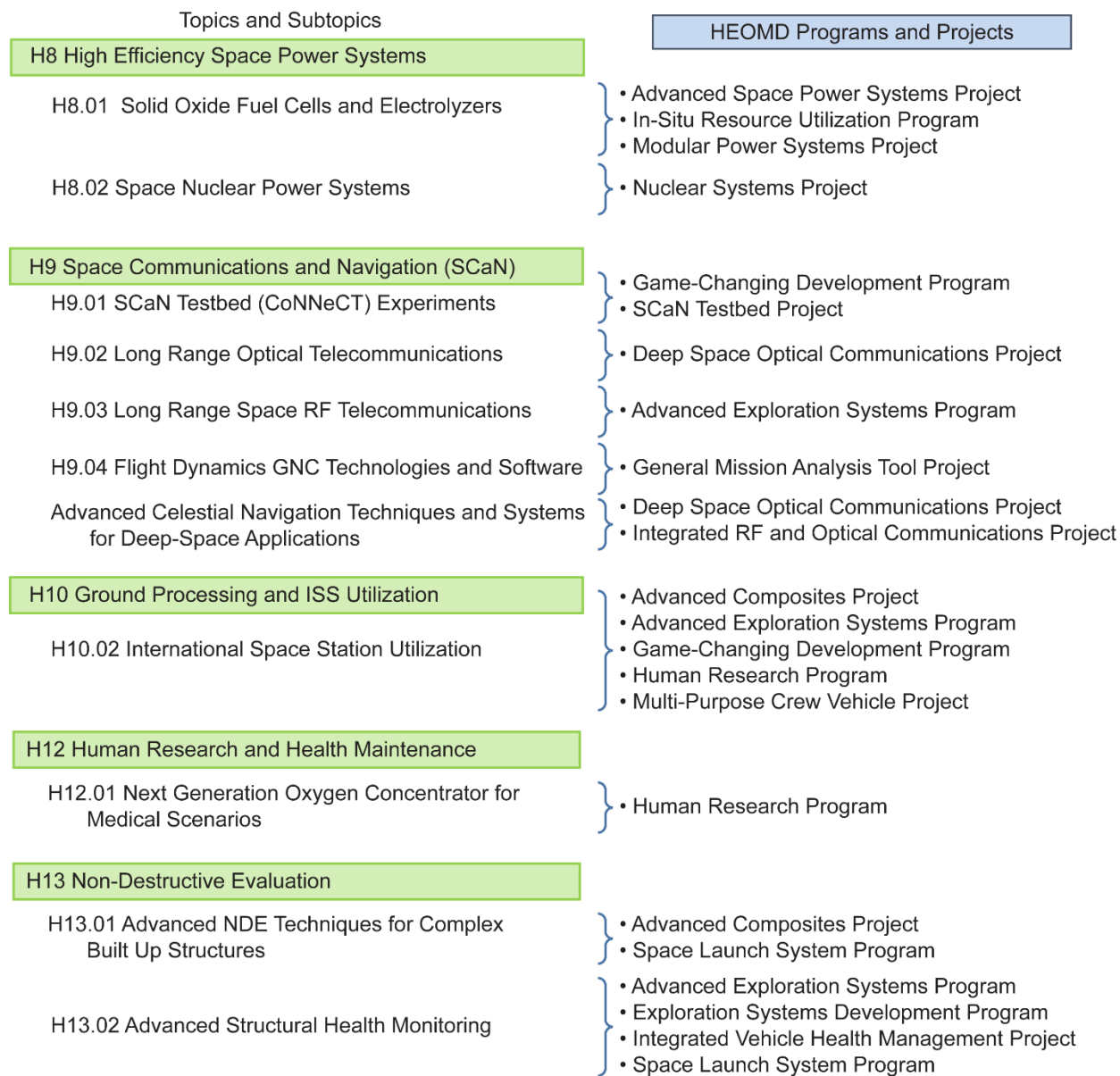


Figure 5.—Concluded.

Adaptable, Deployable Entry Placement Technology Project

This project is a game changing technology development project to develop, test and demonstrate a deployable aeroshell concept as a viable thermal protection system (TPS) for entry, descent and landing (EDL) of science and exploration class payload missions.

Advanced Air Transportation Technology Project

Explores and develops technologies for advanced fixed-wing transport aircraft with revolutionary energy efficiency. These technologies are critical to reduce the environmental impact of aviation as the industry continues to grow. Advanced Air Transportation Technologies studies focus on the future and target vehicles that are three generations beyond the current state of the art that require mature technology solutions in the 2025 to 2035 timeframe.

Advanced Composites Project

NASA is addressing improved methods, tools, and protocols to reduce the development and certification timeline for composite materials and structures. It is inevitable that composite structures will see increased application due to the pressure to develop more efficient, sustainable vehicles. NASA will focus on the development and use of high fidelity and rigorous computational methods, improved test protocols, standardized inspection techniques, and manufacturing process simulation to shorten the timeline to bring innovative composite materials and structures to market.

Advanced Exploration Systems Modular Power Systems Project

It will infuse and demonstrate modular power electronics, batteries, fuel cells, and autonomous control for exploration ground system demonstrations; assess and provide recommendations for improvements of proposed power systems for other Advanced Exploration Systems (AES) projects/HEOMD demonstration systems; and develop modular power design concepts that will guide the ground system demonstrations and modular component and assembly development for the duration of this project.

Advanced Exploration Systems Advanced Space Suit Project

This project develops component technologies for advanced space suits to enable humans to conduct “hands-on” surface exploration and in-space operations outside habitats and vehicles. Technology development includes portable life support systems, thermal control, power systems, communications, avionics, and information systems, and space suit materials.

Advanced Exploration Systems Life Support Systems Project

This project is improving the reliability of water recycling, air revitalization, and environmental monitoring systems using ground test beds.

Advanced Exploration Systems Program

NASA’s Advanced Exploration Systems (AES) program is pioneering approaches for rapidly developing prototype systems, demonstrating key capabilities, and validating operational concepts for future human missions beyond Earth orbit. AES activities are uniquely related to crew safety and mission

operations in deep space, and are strongly coupled to future vehicle development. AES development is focused in four main areas: Crew Systems, Vehicle Systems, Operations, and Robotic Precursor Activities.

Advanced Space Power Systems Project

Project will carry three project elements: advanced regenerative fuel cells, which include fuel cells and electrolyzers and balance of plant subsystems using an innovative passive fluid management technology; advanced high specific energy and energy density lithium-ion batteries with flame retardant electrolytes; and next-generation low-cost, high-power, space-tolerant solar power arrays that integrate advances in cell and manufacturing processing to achieve the end goals

Exploration Systems Development Program

NASA's Exploration Systems Development is building the agency's crew vehicle, next generation rocket, and ground systems and operations to enable human exploration throughout deep space. The Orion spacecraft, Space Launch System (SLS) and a modernized Kennedy spaceport will support missions to multiple deep space destinations extending beyond our Moon, to Mars and across our solar system. This innovative approach aligns with NASA's bold new mission to design and build the capability to extend human existence to deep space.

Cryogenic Propellant Storage and Transfer Project

This project is to reformulate from a spaceflight technology demonstration project to a ground technology demonstration project based on the directorate's budget environment.

Deep Space Optical Communications Project

The objective of this Deep Space Optical Communications Project is to develop key technologies for the implementation of a deep space optical transceiver and ground receiver that will enable greater than 10X the data rate of a state-of-the-art deep space RF system (Ka-band) for similar spacecraft mass and power. Although a 10X RF deep space optical transceiver could be built with existing technologies, the mass and power performance for the data rate provided would not be competitive with existing RF telecommunications systems.

Deployable Entry and Placement Technology Program

ADEPT is a game changing technology development project to develop, test and demonstrate a deployable aeroshell concept as a viable thermal protection system (TPS) for entry, descent and landing (EDL) of science and exploration class payload missions. Its concept is a mechanically deployable semi-rigid aeroshell entry system capable of achieving low ballistic coefficient during entry suitable for a variety of planetary or earth return missions leveraging Ames' expertise in TPS material and entry system design, development and testing.

Evolvable Cryogenics Project

Tasks are being formulated for cryogenic fluid management technologies that will support development of the Space Launch System and make use of large-scale systems to assess performance of numerous technologies such as vapor cooling, multilayer insulation, gauging and analytical models.

Game-Changing Development Program

This program seeks to identify and rapidly mature innovative/high impact capabilities and technologies that may lead to entirely new approaches for the Agency's future space missions. The program will investigate novel ideas and approaches that have the potential to revolutionize future space missions. The most promising ideas will be advanced through significant ground-based testing and or laboratory experimentation typically by multiple performing teams using varied approaches.

General Mission Analysis Tool Project

GMAT is a software system for trajectory optimization and mission analysis. Analysts use GMAT to design spacecraft trajectories, optimize maneuvers, visualize and communicate mission parameters, and understand a mission's trade space. The GMAT project is a collaborative effort between NASA, the space community, and the open source community.

Green Propellant Infusion Mission Program

Through the Green Propellant Infusion Mission, or GPIM, NASA is developing a "green" alternative to conventional chemical propulsion systems for next-generation launch vehicles and spacecraft. The new green propellant will be an enabling technology for commercial spaceports operating across the U.S. With the green propellant, launch vehicle and spacecraft fuel loading will be safer, faster and much less costly. The "shirt sleeve" operational environment GPIM offers will change ground processing time from weeks to days. Building and operating satellites will be simplified.

Heatshield for Extreme Entry Environment Technology Project

This project seeks to mature a game changing Woven Thermal Protection System (TPS) technology to enable in situ robotic science missions recommended by the NASA Research Council Planetary Science Decadal Survey committee.

Human Health Countermeasures Element Project

It is responsible for understanding the normal physiologic effects of spaceflight and developing countermeasures to those with detrimental effects on human health and performance. It provides the biomedical expertise for the development and assessment of medical standards, vehicle and spacesuit requirements and countermeasures that ensure crew health during all phases of flight

Human Research Program

HRP delivers products and strategies to protect the health and safety of spaceflight crews and increase their productivity while living and working in space. The project investigates and mitigates the highest risks to human health and performance, providing essential countermeasures and technologies for human space exploration. Risks include physiological and performance effects from hazards such as radiation,

altered gravity, and hostile environments, as well as unique challenges in medical support, human factors, and behavioral health support.

Hypersonic Inflatable Aerodynamic Decelerator Project

The Hypersonic Inflatable Aerodynamic Decelerator (HIAD) project will focus on the development and demonstration of hypersonic inflatable aeroshell technologies suitable for an ISS down-mass capability. The project will focus on the completion of an IRVE-3 development flight test and other necessary analysis and ground-based testing. The key technologies include flexible TPS materials for hypersonic entry conditions, attachment and inflation mechanism and high-strength, lightweight, inflatable bladder materials capable of withstanding high temperatures.

In-Situ Resource Utilization Program

The In-Situ Resource Utilization (ISRU) works to assess the in situ resources available on the moon and Mars in addition to developing technologies needed to utilize these resources. The research will focus on technologies necessary to extract consumables (O₂, H₂O, N₂, He, etc.) for human life-support system replenishment. The consumables will also be used as source materials (feedstock) for In Situ Fabrication and Repair (ISFR) technologies as well as feedstock for radiation shielding and shelters.

Integrated Vehicle Health Management

Integrated Vehicle Health Management (IVHM) systems are being developed for the Second Generation Reusable Launch Vehicle (RLV), crew, and cargo transfer vehicles. These highly integrated systems will likely include advanced smart sensors, diagnostic and prognostics software for sensors and components, model based reasoning systems for subsystem and system level managers, advanced on-board and ground-based mission and maintenance planners, and a host of other software and hardware technologies.

Integrated RF and Optical Communications Project

The iROC Project combines the best features of select deep space radio frequency (RF) and optical communication elements into an integrated system. The project is working on increasing Technology Readiness Levels (TRLs), leading to integrated hybrid communications system demonstration. These new systems offer potential 40x (optical) and 16x (RF) data rates with comparable MRO payload mass. Additionally, deep space mission risk for transition to optical communication technology will be reduced by integrating highly capable and robust RF system (extensible design beyond Mars).

Low Cost Upper Stage-Class Propulsion Project

The Low Cost Upper Stage-Class Propulsion (LCUSP) Element will develop a high strength copper alloy additive manufacturing process, as well as, critical components for an upper stage-class propulsion system which will be demonstrated with testing.

Materials Genome Initiative Project

The Materials Genome Initiative (MGI) is a multi-agency initiative designed to create a new era of policy, resources, and infrastructure that support U.S. institutions in the effort to discover, manufacture,

and deploy advanced materials twice as fast, at a fraction of the cost. The National Aeronautics and Space Administration (NASA) provides MGI with the unique platform of continued understanding of materials for use on launch vehicles and other infrastructure that will be exposed to extreme environments. The goals, objectives, and priorities of MGI align with NASA's Technology roadmap 12: Materials, Structures, Mechanical Systems, and Manufacturing, specifically in the area of computational design of materials.

Modular Power Systems Project

The AES Modular Power Systems (AMPS) project will infuse and demonstrate modular power electronics, batteries, fuel cells, and autonomous control for exploration ground system demonstrations; assess and provide recommendations for improvements of proposed power systems for other Advanced Exploration Systems (AES) projects/HEOMD demonstration systems; and develop modular power design concepts that will guide the ground system demonstrations and modular component and assembly development for the duration of this project.

Multi-Purpose Crew Vehicle Project

Multi-Purpose Crew Vehicle (MPCV) is designed to meet the evolving needs of our nation's beyond low Earth orbit space exploration program for decades to come. The MPCV features dozens of technology advancements and innovations that have been incorporated into the spacecraft's subsystem and component design. The MPCV spacecraft includes both crew and service modules, a spacecraft adaptor, and a revolutionary launch abort system that will significantly increase crew safety.

Next Generation Life Support Project

The Next Generation Life Support (NGLS) project is developing key technologies to enable critical capabilities in Extravehicular Activity (EVA) Portable Life Support System (PLSS), life support oxygen recovery, and life support water recovery required to extend human presence beyond low Earth orbit into the solar system. The selected technologies within each of these areas are focused on increasing affordability, reliability, and vehicle self-sufficiency while decreasing mass and enabling long duration exploration.

Nuclear Systems Project

This project will initiate the development of a low-cost, small fission terrestrial demonstration. The 3-year development effort will result in the demonstration of a fission power system using a prototype U235 reactor core coupled to flight-like Stirling converters

Nuclear Thermal Propulsion Program

This project is developing system concepts, ground test approaches, and reactor fuel elements for nuclear thermal propulsion. A key goal of the project is to address critical, long-term nuclear thermal propulsion (NTP) technology challenges and issues through development, analysis, and testing of NTP hardware so NTP systems can be an affordable and viable in-space propulsion candidate for future HEO missions.

Packed Bed Reactor Experiment Project

There is very little understanding of how the reduced gravity environment affects the performance and reliability of the reactors. This is especially critical when the reactor involves simultaneous gas and liquid flows. The Packed Bed Reactor Experiment (PBRE) is designed to specifically resolve these technology gaps. The expected outcome of this research effort is to develop a set of guidelines and tools to enable engineers to reliably design and operate fixed packed bed reactors for microgravity as well as the lunar and Martian environments.

Radioisotope Power System Program

It is a technology development effort, managed by NASA that is strategically investing in nuclear power technologies that would maintain NASA's current space science capabilities and enable future space exploration missions. NASA, working in collaboration with the U.S. Department of Energy (DOE), invests in research and development efforts on the Advanced Stirling Radioisotope Generator (ASRG). NASA also works with DOE to maintain the capability to produce the Multi-Mission Radioisotope Thermoelectric Generator (MMRTG), which serves as the power source for the Mars Science Laboratory rover, Curiosity.

SCaN Testbed Project

The SCaN Testbed is an advanced integrated communications system and laboratory facility to be installed on the International Space Station (ISS). Using a new generation of Software Defined Radio (SDR) technologies, this ISS facility will allow researchers to develop, test, and demonstrate new communications, networking, and navigation capabilities in the actual environment of space. The SCaN Testbed will thus advance space communication technologies in support of future NASA missions and other U.S. space endeavors.

Small Spacecraft Technology Program

The Small Spacecraft Technology Program, one of the nine programs in the Space Technology Mission Directorate, has three primary objectives (1) Identify and support the development of new subsystem technologies to enhance or expand the capabilities of small spacecraft, (2) Support flight demonstrations of new technologies, capabilities and applications for small spacecraft, and (3) Use small spacecraft as platforms for testing and demonstrating technologies and capabilities that might have more general applications in larger-scale spacecraft and systems

Solar Electric Propulsion Program

Develop and fly a 50 kW spacecraft that uses flexible blanket solar arrays for power generation and electric propulsion for primary propulsion and is capable of delivering payload from LEO to higher orbits and into deep space.

Space Communications and Navigation Program

It serves as the Program Office for all of NASA's space communications activities. SCaN manages and directs the ground-based facilities and services provided by the Deep Space Network (DSN), Near Earth Network (NEN), and Space Network (SN).

Space Launch System Program

NASA's Space Launch System, or SLS, is an advanced launch vehicle for a new era of exploration beyond Earth's orbit into deep space. SLS, the world's most powerful rocket, will launch astronauts in the agency's Orion spacecraft on missions to an asteroid and eventually to Mars, while opening new possibilities for other payloads including robotic scientific missions to places like Mars, Saturn and Jupiter.

Transformational Tools and Technologies Project

Develops new computer-based tools, models, and associated scientific knowledge that will provide first-of-a-kind capabilities to analyze, understand, and predict performance for a wide variety of aviation concepts. Examples of research areas include predicting flow around vehicles and improving the understanding of strong and lightweight materials for aviation.

The Vehicle Systems Safety Technologies Project

It provides knowledge, concepts, and methods to avoid, detect, mitigate, and recover from hazardous flight conditions, and to maintain vehicle airworthiness and health.

Appendix A.—Fiscal Year 2015 Phase I Contract Titles That Glenn Research Center Leads and Participates

The following FY 15 Phase I contract subtopics that Glenn leads and participates in are posted at <http://sbir.nasa.gov/SBIR/abstracts/15-1.html>

H1.01-9186	Task-Specific Asteroid Simulants for Ground Testing
H1.01-9278	Demonstration of “Optical Mining” For Excavation of Asteroids and Production of Mission Consumables
H1.01-9564	Small Body Regolith Extraction System
H1.01-9667	Planetary Volatiles Extractor for In Situ Resource Utilization
H1.01-9764	Carbonaceous Asteroid Volatile Recovery (CAVoR) system
H1.01-9984	Microwave Extraction of Water from Boreholes in Regolith
H2.01-8819	ORSC Methane Ascent/Descent Engine Technology Development
H2.01-8863	In-Space LOX/Methane Pintle Propulsion Engine (LMPPE) Evaluation and Demonstration
H2.01-8906	Low-Cost, Lightweight Transpiration-Cooled LOX/CH ₄ Engine
H2.01-9172	Bulk Nano-structured Materials for Turbomachinery Components
H2.01-9267	Thermo-Catalytic Ignition of Cryogenic Oxygen-Methane
H2.01-9296	Additively Manufactured Monolithic LOX/Methane Vortex RCS Thruster
H2.01-9299	Additive Manufacturing Applied to LOX - Methane Turbopumps
H2.01-9651	Enabling Pump Technologies for Deep Throttle Ascent/Descent Engine Operation
H2.01-9859	Small-Scale, Methane-Fueled Reaction Control Engines for In-Space Propulsion
H2.02-8968	Long Life Bearings for Nuclear Thermal Propulsion
H2.02-9101	Advanced Zirconium Carbide Tie-Tubes for NTP
H2.02-9127	Passive Technology to Improve Criticality Control of NTP Reactors
H2.02-9359	Extreme Temperature Radiation Tolerant Instrumentation for Nuclear Thermal Propulsion Engines
H2.03-8803	Integrated Energetic Ion Mitigation for High Power Plasma Cathodes
H2.03-9179	Rapid Manufacturing of High Power Electric Propulsion Components
H2.04-8862	Pulsating Heat Pipe for Cryogenic Fluid Management
H2.04-8901	Parahydrogen-Orthohydrogen Catalytic Conversion for Cryogenic Propellant Passive Heat Shielding
H2.04-9218	Vapor Cooled Structure MLI: Efficient Vapor Cooling of Structural Elements
H2.04-9337	Fabric, Inflated, Insulating Shroud for Cryogenic In-Space Transportation
H2.04-9559	Integrated Launch Vehicle – Load Responsive MLI: High Performance during Launch Ascent, In-Air, On-Orbit and On-Mars
H2.04-9987	Light Weight Insulated Spherical Cryotank
H3.01-8848	An Airborne Particulate Monitor for Spacecraft
H3.01-8900	Microchip Capillary Electrophoresis for In Situ Water Analysis
H3.01-9305	Reagent Regenerative Microgravity Compatible Inorganic Ion Analyzer

H3.01-9673	Spacecraft Potable Water Monitor
H3.01-9921	Rapid Concentration for Improved Detection of Microbes in ISS Potable Water
H3.03-8782	Multifunctional Dust Filters for Crew Cabin Air Purification
H3.03-8856	A Robust, Gravity-Insensitive, High-Temperature Condenser
H3.03-9079	Designer Fluid for use in a Single Loop Variable Heat Rejection Thermal Control System
H3.03-9254	Oxygen Recovery From Carbon Dioxide Through Electrolysis
H3.03-9701	Nautilus Centripetal Capillary Condenser
H4.03-9054	E VA Space Suit Power, Avionics, and Software Systems
H4.03-9399	Compact Wireless EVA Communications System (CWECS)
H4.03-9650	Audio ADC
H5.01-8614	Advanced Composite Truss (ACT) Printing for Large Solar Array Structures
H5.01-8958	X-Boom
H5.01-9228	Robust, Highly Scalable Solar Array System
H5.01-9640	Compact Telescoping Array Design and Development
H5.01-9790	Active Gravity Offloading System for Deployable Solar Array Structures
H5.01-9816	Lightweight Inflatable Structural Airlock (LISA)
H5.03-9416	Multifunctional Composite for Integrated Strain, Damage and Temperature Sensing
H5.03-9682	Ultrasonic Additive Manufacturing for Multifunctional Structural Materials with Embedded Capabilities
H5.03-9735	Metamaterials-Inspired Aerospace Structures (MIAS)
H5.03-9848	In-Situ Sensing for Multi-Functional Structures
H7.01-8805	Investigation of Effect of High, Short Duration Temperatures on Fiber Graphitization and Resulting Property Changes in 3D Woven TPS Preforms During Entry Trajectories
H7.01-9025	Embedded Multifunctional Optical Sensor System
H7.01-9767	Heat Shield Recession Measurements Using Remote Spectral Sensors
H7.01-9872	Next generation HgCdTe FPAs for high frame rate characterization of thermal protective systems
H8.01-8888	Ultra-Compact Heat Rejection System for Fission Surface Power
H8.01-8946	Pulsating Heat Pipes
H8.02-9587	Efficient, High Power Density Hydrocarbon-Fueled Solid Oxide Stack System
H8.02-9936	Room Temperature Electrolyzers For Oxygen Generation On Mars
H8.03-9072	Radiation Hard, High Efficiency, Quadruple Junction Solar Cells Based on InGaAsN
H8.03-9093	Light-Weight, Flexible, High Efficiency Vacuum Photo-Thermo-Voltaic Solar Cells
H9.01-8772	Electro-Optically Scanned Micro-Laser Communication Module
H9.01-8987	Single-photon Lasercom Readout Integrated Circuit (ROIC)
H9.01-8990	High Channel Count Time-to-Digital Converter and Lasercom Processor
H9.01-9298	NASA Laser Communications with Adaptive Optics and Linear Mode Photon Counting

H9.01-9619	100W High Efficiency 1550 nm Pulsed Fiber Laser
H9.01-9626	High Average Power Fiber Laser for Satellite Communications
H9.01-9686	Stable Platform for Optical Communications (SPOC)
H9.02-9004	Cognitive Engine enabled Mission-aware Intelligent Communication System for Space Networking
H9.03-9090	World-Class Visualizations in GMAT
H9.03-9689	Improved Navigation for Highly Dynamic Environments
H10.01-8807	MEMS Sensor Arrays for Cryogenic Propellant Applications
H10.01-8824	Highly Efficient Electrochemical Cryogenic Purge Gas Recovery System
H10.01-8857	Multi-Species Chemical Microsensor For Real Time Cryogenic Purge Line Monitoring
H10.01-8880	Integrated Stack and Advanced MEAs for High-Yield, Long-Life Helium Reclamation System
H10.01-8895	Helium Recovery System Based on High-Performance Proton Exchange Membranes
H12.01-9633	Optical System for Monitoring Net Ocular Blood Flow
H13.02-8642	An Advanced Ultrasonic Imaging System using Time-Reversal MUSIC Technique for Rapid Inspection of Ultra Large, Complex Composite Structures
H13.02-8935	Reconfigurable Optical Velocimeter for Autonomous Structural Inspection in Space (ROVASIS)
H13.02-9289	Microwave Inspection Nondestructive Imaging Array
H13.02-9522	Space Vehicle Inspection High Range Resolution & Raman Spectral LIDAR
H14.01-9251	ISS Testbed for Capillary Two-Phase Flow Device Qualification
H14.01-9375	Multi Phase Flow Decomposition and Imaging Using Electrical Capacitance Volume Tomography Sensors
H14.01-9699	LMM Holographic Optical Tweezers (HOT) Module
H14.01-9736	Electrical Microgravity Research in Colloidal Development Platform
H14.01-9875	Rodent Centrifuge Facility for ISS Life and Microgravity Science Research
H14.01-9877	Snap Freezer for ISS

Appendix B.—Fiscal Year 2014 Phase II Contract Titles That Glenn Research Center Leads and Participates

The following FY 14 Phase II contract subtopics that Glenn leads and participates in are posted at <http://sbir.nasa.gov/SBIR/abstracts/14-2.html>

H1.01-8645	Innovative High Efficiency Filter for Mars Dust
H1.01-9247	Carbon Dioxide Collection and Pressurization Technology
H2.01-8812	Fast Acting Flow Control Valve
H2.01-9770	Reservoir Scandate Cathode for Electric Propulsion
H2.02-9229	Manufacturing Advanced Channel Wall Rocket Liners
H2.02-9347	100-lbf Non-Toxic Storable Liquid Propulsion
H2.03-8602	Cellular Load Responsive MLI: Structural In-Air and In-Space LH2 Insulation
H2.03-9718	Superconducting Electric Boost Pump for Nuclear Thermal Propulsion
H3.01-9785	Vapor Chamber with Phase Change Material-Based Wick Structure for Thermal Control of Manned Spacecraft
H3.02-9264	Highly Efficient, Solid State Hydrogen Purification for Resource Recovery
H3.02-9398	An Advanced Smoke-Eater for Post-Fire Cabin Atmosphere Cleanup
H3.02-9843	High Pressure Oxygen Generation for Future Exploration Missions
H5.01-9108	Laser-Directed CVD 3D Printing System for Refractory Metal Propulsion Hardware, Phase II
H5.01-9602	New methods of In-Situ Metrology and Process Control for EBF3 Additive Manufacturing
H5.02-9115	Spirally Stowed Architecture for Large Photovoltaic Arrays
H5.02-9544	Ultra-Flexible Advanced Stiffness Truss for Large Solar Arrays
H7.01-9198	High Heat Flux Block Ablator-in-Honeycomb Heat Shield Using Ablator/Aerogel-Filled Foam, Phase II
H7.01-9726	Thermal Protection Systems Nondestructive Evaluation Tool
H7.01-9779	Integration of Complex Geometry, 3D Woven Preforms via Innovative Stitching Technique
H8.01-8950	High Efficiency Direct Methane Solid Oxide Fuel Cell System
H8.01-9741	Fabrication of T-SOFC via Freeze Cast Methods for Space and Portable Applications
H8.02-9974	Titanium-Water Heat Pipe Radiator for Spacecraft Fission Power
H9.02-9962	20 W High Efficiency 1550 nm Pulsed Fiber Laser
H9.03-9656	High-Efficiency, Ka-Band Solid-State Power Amplifier Utilizing GaN Technology

H9.05-9750 Interferometric Star Tracker, Phase II

H10.02-8917 Low-Cost Small Reentry Devices to Enhance Space Commerce and ISS Utilization
H10.02-9120 rHEALTH X with Non-Invasive Capabilities for Science and Crew Health

H12.01-9406 A Low-Power Medical Oxygen Generator

H13.01-8549 Spatially Coherent Optical Velocimeter Array for Rapid Guided-wave NDE

H13.02-9598 Passive Wireless Sensor System for Structural Health Monitoring

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